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(54) **Method and apparatus for determining an alternate route in a vehicle navigation system**

(57)   A method and apparatus for determining an alternate route from a new source location located on an original route to a subsequent location on the original route using a vehicle navigation system are described. A portion of the original route to be avoided by the alternate route is determined which begins at the new source location. The portion of the original route includes a plurality of segments each of which has an original parameter associated therewith. Selected ones of the original parameters are adjusted thereby resulting in a plurality of adjusted parameters. The alternate route is then determined based in part on the adjusted parameters.
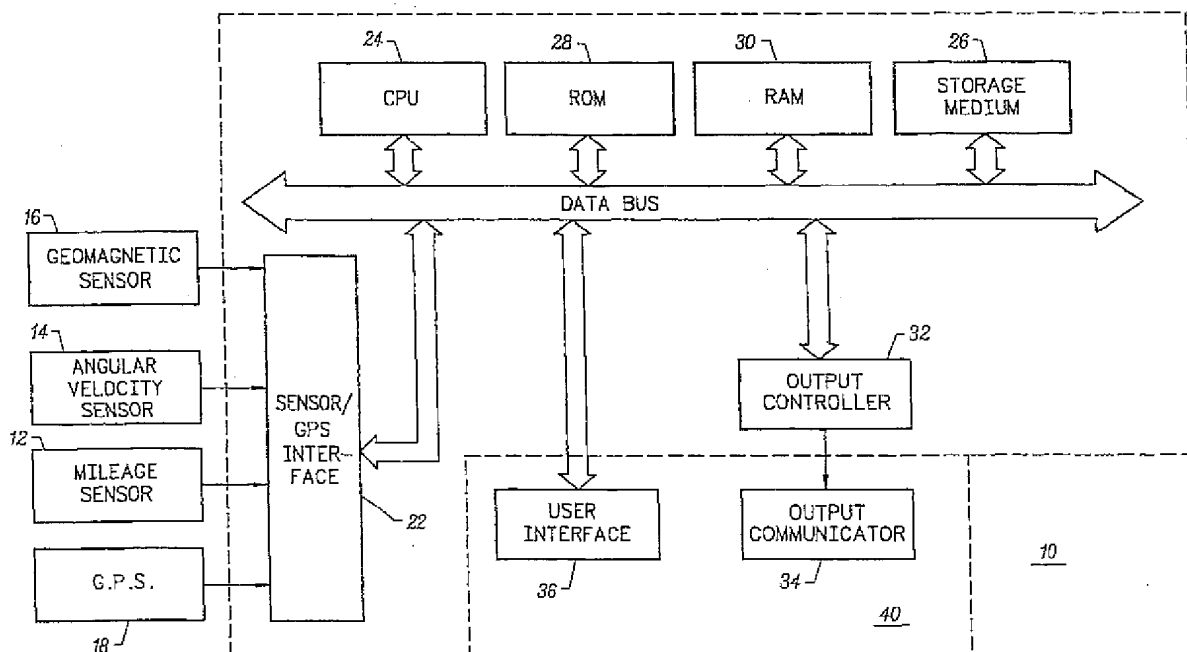
FIG. 3

EP 0 854 463 A2

Description

The present invention relates to route determination in a vehicle navigation system. Arrangements to be described below, by way of example in illustration of the present invention are concerned with the determination of alternate routes, i.e., detours, when road conditions make an originally determined route undesirable or impassable.

Because updating map databases with up-to-the-minute information regarding road conditions is an exceedingly challenging task (even for so-called intelligent vehicle/highway systems), currently available vehicle navigation systems often determine routes on which the user may encounter unforeseen or unforeseeable obstacles such as, for example, road construction or excessive traffic. In such situations it is desirable for the navigation system to have the capability to determine an alternate route "on the fly" to avoid the obstacle.

Some systems rely on user input to the route determination algorithms to determine routes which are most likely to be the easiest and fastest, i.e., the optimum route. By prospectively selecting appropriate route determination criteria, knowledge of actual road conditions can be employed by a user to facilitate the determination of the best available route. For example, a user may specify that the system make maximum use of freeways, or, alternatively, that no freeways be used at all. A user may also specify that the route should have a minimum number of turns, or that it be the shortest distance between the source and the destination. In addition, a user may specify that the route should avoid all known obstacles such as, for example, toll booths. Unfortunately, while this approach provides some flexibility, it cannot anticipate and correct for road obstacles for which the user has little or no warning.

One approach to "on the fly" obstacle avoidance allows the user to tell the system to prohibit an upcoming manoeuvre in response to which the system determines a short detour from the point of the prohibited manoeuvre back to some subsequent point on the original route.

Reference will now be made to Figs. 1 and 2 of the accompanying drawings which enable respective previously proposed approaches to generating alternate routes known to the applicants to be described. Referring to Fig. 1, it will be seen that, as a user proceeds east on road 102 along original route 104, it will be noticed by the user that road 106 is closed to the right because of construction. As a result, the right turn manoeuvre suggested by the system is impossible. By refusing to carry out the manoeuvre indicated by the user interface, the user alerts the system to the obstacle. The system then determines an alternate route 108 based on the assumption that the right turn manoeuvre from road 102 to road 106 is not allowed. This results in the detour via roads 110 and 112 which leads back to road 106 as soon as possible.

Unfortunately, the above-described approach is problematic where, for example, the entire portion of road 106 between roads 102 and 114 is closed. Such a situation is addressed by another approach which will be described with reference to Fig. 2. As in the previous example, the user alerts the system to the fact that the right turn manoeuvre on to road 106 is not possible. However, according to this approach, the system avoids the portion of road 106 between the two successive manoeuvres at the intersection of roads 102 and 106 (i.e., the right turn mentioned above), and the intersection of roads 106 and 114 (a left turn). By ignoring the road segments between the next two upcoming manoeuvres, an alternate route 202 is determined which avoids the problem discussed above.

However, despite the apparent advantages offered by each of these approaches, none allows the user to contribute input as to the nature of the alternate route based on the perception of the road conditions by the user. Thus, none of the above- described approaches is sufficient to adapt to the high degree of variability of road conditions which may be encountered by a user. A more flexible approach to "on the fly" determination of alternate routes is therefore desirable.

A feature of a method and apparatus to be described below, by way of example in illustration of the present invention for "on the fly" determination of alternate routes in a vehicle navigation system is that it allows the user to specify the portion of the original route to be avoided by the alternate route. This enables the navigation system to generate alternate routes which bear some relation to the actual road conditions encountered by the user. That is, based on the user's perception of the road conditions, the user may specify a distance along the original route from the current vehicle position which is to be avoided by the alternate route. The system then adjusts one or more parameters associated with each of the segments in the original route within the specified distance such that when the alternate route is generated, these segments will tend to be avoided.

In one embodiment to be described by way of example in illustration of the invention, the system increases the cost associated with each segment in the portion of the original route specified by the user. The amount by which each cost value is increased varies according to its distance from the vehicles current location, i.e., the starting point of the alternate route. That is, the closer a segment is to the current vehicle position, the greater is its cost increment. In this way, the alternate route determination algorithm tends to avoid completely the original route segments immediately following the starting point of the alternate route, with this avoidance tendency lessening somewhat as the algorithm encounters segments which are farther along the original route.

A method and apparatus will be described below, by way of example in illustration of the invention, for determining an alternate route from a new source location located on an original route to a subsequent location on the original route using a vehicle navigation system. A

portion of the original route to be avoided by the alternate route is determined beginning at the new source location. The portion of the original route includes a plurality of segments each of which has an original parameter associated therewith. Selected ones of the original parameters are adjusted thereby resulting in a plurality of adjusted parameters. The alternate route is then determined based in part on the adjusted parameters.

The following description and Figs. 3 to 6 of the drawings disclose, by means of examples, the invention which is characterised in the appended claims, whose terms determine the extent of the protection conferred hereby.

In the drawings:-

Fig. 3 is a block schematic diagram of a specific embodiment of a vehicle navigation system for use with the present invention,

Figs. 4A and 4B illustrate a specific embodiment illustrative of the present invention,

Fig. 5 is a table of cost values corresponding to a specific embodiment illustrative of the present invention, and

Fig. 6 is a flowchart illustrating a specific embodiment illustrative of the invention.

It may be helpful in considering the present invention to refer to United States Patents No. 5,345,382, No. 5,359,529, No. 5,374,933 and No. 5,515,283.

Referring now to Fig. 3 there is shown a vehicle navigation system 10 for use with the present invention having sensors 12 and 14 and GPS receiver 18 coupled to computing means 20 through sensor/GPS interface 22. In typical embodiments, mileage sensor 12 is an odometer, and angular velocity sensor 14 is a gyroscope, or a differential odometer coupled to the wheels of the vehicle. A global positioning system (GPS) data receiver 18 is provided for receiving signals from, for example, a satellite-based navigation system. Data from sensor/GPS interface 22 is transmitted to CPU 24, which performs calibration, signal processing, dead-reckoning, vehicle positioning, and route guidance functions. A database containing map information may be stored in database medium 26, with software directing the operation of computing means 20 stored in main memory 28 for execution by CPU 24. Memory 28 may comprise read-only memory (ROM), or reprogrammable non-volatile memory such as flash memory or SRAM. System RAM 30 permits reading and writing of the information necessary to execute such software programs. Database medium 26 may comprise non-volatile memory, a hard disk drive, CD-ROM, or an integrated circuit in which digitized map information has been stored. Output controller 32, which may comprise a graphics controller, receives data processed by CPU 24 and transmits the data to display console 40 which includes output communicator 34, usually comprising a display screen with associated audio electronics and audio speakers. The

driver may input data, such as a desired destination, through user interface 36, typically comprising a keyboard.

The map database stored in database medium 26 preferably comprises positional data such as, for example, latitude and longitude coordinates, to describe road intersections or nodes, road segments, landmarks and points of interest, and other geographical information. The data base may further comprise data representing characteristics of roads or places on the map, such as road and place names, road features such as dividers, one-way restrictions, surface, speed limit, shape, elevation, and other properties. In one embodiment illustrative of the invention, the map database includes cost values associated with individual nodes and road segments. These cost values correspond to the estimates of time intervals for traversing the respective node or segment. Node cost values take into consideration such information as, for example, whether the vehicle would encounter oncoming traffic, thus delaying a left turn manoeuvre. Segment costs reflect road segment characteristics such as speed limit and segment length, both of which affect the travel time along the segment. Also associated with each road in the map database is a link class which relates to the category or type of the road. For example, the highest level category of the hierarchy is the link class FREEWAY. The lowest level includes the link classes FRONTAGE and MISC which include, for example, frontage roads and alleys.

One vehicle navigation system illustrative of the invention is operable to generate a route from a source location to a destination according to a variety of different methods. Some examples of such methods are described in the U.S. patents which are mentioned above. In addition, further methods for route generation may be employed in conjunction with the present invention.

Figs. 4A and 4B will serve to illustrate the operation of a specific embodiment illustrative of the invention. Initially, an original route 402 (along roads 404, 406, and 408) is generated by the vehicle navigation system as described above. As the user proceeds from source S along road 404, excessive traffic is encountered (or any of a variety of road obstacles) which activates a key or a switch on the user interface and informs the system that the user wishes to avoid a portion of original route 402. The display screen progression is shown in Fig. 4B. As the user is proceeding along road 404, the next upcoming manoeuvre, i.e., left turn on road 406, is shown on display screen 410. When the user hits the "avoid" key, there is presented the AVOID CURRENT ROUTE screen 412 in which the user may scroll to a desired distance and hit "enter". The distances may be in miles as shown. Alternatively, the distances may be presented to the user as a number of road segments, city blocks, etc. In another embodiment, the user may directly input any desired distance within a range.

Upon the user's selection of the distance, the system generates an alternate route 414 and communi-

cates a new upcoming manoeuvre to the user (screen 416) - In generating alternate route 414 the system increases the cost associated with selected ones of the segments in the portion of original route beginning at the intersection of roads 404 and 418 and extending the selected distance. The manner in which this is accomplished in one particular embodiment illustrative of the invention may be understood with reference to Fig. 4A and table 500 in Fig. 5. As shown in Fig. 4A, original route 402 includes segments S1 -S13. In generating an alternate route, the cost associated with each of these segments is increased by an amount shown in table 500. The cost values in table 500 are measured in seconds, but it will be understood that such costs may be represented in a number of ways.

As shown in the table, as the segment numbers increase, i.e., as the distance from the road obstacle increases, the cost added to the segment cost associated with each successive segment is gradually decreased to zero. The decrement and rate of this decrease depends upon the distance of the original route to be avoided as specified by the user. Thus, the closer the segment is to the road obstacle, the more likely that the alternate route generation algorithm will ignore it because of the dramatic increase in cost. Similarly, as the segments recede from the road obstacle, the likelihood that the algorithm will ignore them decreases until the alternate route includes a segment from the original route, i. e., segment S9.

It will be understood that the above-described embodiment may be modified to include the manipulation of node costs in place of, or in addition to, the manipulation of segment costs. Node costs are the costs associated with traversing a map node such as, for example, an intersection. The node cost for a particular intersection may be determined without regard to a particular route. It may also be determined to specifically reflect the traversal of the intersection from one specific segment to another. According to such an embodiment, node costs may be manipulated in much the same way as shown in Fig. 5 with regard to segment costs. The manipulated node costs may then be used to determine the alternate route either in place of the segments' costs, or in addition to them.

Fig. 6 is a flowchart 600 which illustrates the operation of a specific embodiment of the invention. The vehicle navigation system being described guides the user along an originally calculated route (step 601) unless it receives an "avoid route" signal in response to input from the user (step 602). The system then presents the user with an 'AVOID CURRENT ROUTE" screen as shown in Fig. 4B (step 604) so that the user may specify how much of the original route to avoid. Upon selection by the user of a portion of the current route to be avoided (step 606), the system generates a detour list which includes segments of the original route beginning with the vehicle's current location and ending at the distance specified by the user (step 608). For selected segments

in the list, the system then increases the costs associated with each (step 610).

As discussed above with reference to Figs. 4A and 5, the cost increment decreases as the distance between the original road segments and the road obstacle increases. Once the costs associated with the original road segments have been increased in this manner, the system generates an alternate route from the vehicle's current location, i.e., the location of the road obstacle, to some subsequent location on the original route (step 612). As discussed above, because of the increased costs associated with the original route segments in the detour list, the system tends to avoid expansion along these segments with the alternate route determination algorithm. This is especially true for the original route segments closest to the beginning of the alternate route because the greatest cost increase is associated with these segments. However, the further the original route segments in the detour list are from the current vehicle location, the less likely they are to be avoided by the search algorithm. In this way, the alternate route determination algorithm eventually includes a segment in the alternate route which coincides with a segment in the original route. Once this occurs, the algorithm terminates (step 614).

While specific embodiments illustrative of the invention have been described by way of example, it will be understood that variations and modifications thereof, as well as other embodiments may be made without departing from the scope of the protection sought by the appended claims. For example, embodiments have been described in which a variable increment is added to the segment costs associated with the road segments in a specified portion of the original route. It will be understood, however, that these costs may be manipulated in a variety of ways within the scope of the protection sought. For example, in contrast to table 500, the cost increment need not be uniformly decremented for each successive segment in the original route. Rather, the cost increment may be fixed for several successive segments.

Moreover, for selected segments in the original route, rather than increasing the associated segments costs, access to such segments (e.g., the first five segments after the road obstacle) may be completely prohibited. Fixed and/or variable cost increments may then be added to successive segments. Thus, a variety of segment parameters (e.g., segment cost) may be manipulated in a variety of ways for the segments in the portion of the original route to be avoided by the alternate route.

Claims

1. A method for use in determining an alternate route from a new source location located on an original route to a subsequent location on the original route

using a vehicle navigation system, the method including the steps of

determining a portion of the original route to be avoided by the alternate route, the portion of the original route beginning at the new source location, and the portion of the original route having a plurality of segments each of which has an original parameter associated therewith,

adjusting selected ones of the original parameters thereby providing a plurality of adjusted parameters, and

determining the alternate route from the new source location to the subsequent location based in part on the adjusted parameters.

2. A method as claimed in claim 1 wherein the first determining step includes the steps of

providing an input device to a user of the vehicle navigation system for selecting a length of the portion of the original route to be avoided by the alternate route, and

determining the portion of the original route in response to input from the user.

3. A method as claimed in claim 2 wherein the input device provides a plurality of length options from which the user makes a selection.

4. A method as claimed in claim 1 wherein the input device allows the user to specify the length of the portion of the original route to be avoided.

5. A method as claimed in claim 1 wherein the parameters include segment costs, the adjusting step including adding an additional cost to selected ones of the segment costs.

6. A method as claimed in claim 5 wherein the additional cost is fixed.

7. A method as claimed in claim 5 wherein the additional cost varies with the distance between the new source location and a particular segment.

8. A method as claimed in claim 7 wherein the additional cost decreases as the distance between the new source location and the particular segment increases.

9. A method as claimed in claim 1 wherein the parameters relate to segment access, the adjusting step including prohibiting access to selected ones of the segments for the determination of the alternate route.

10. A method as claimed in claim 1 wherein the parameters include node costs, the adjusting step including adding an additional cost to selected ones of the node costs

11. A method as claimed in claim 10 wherein the additional cost is fixed.

12. A method as claimed in claim 10 wherein the additional cost varies with the distance between the new source location and a particular node.

13. A method as claimed in claim 12 wherein the additional cost decreases as the distance between the new source location and the particular node increases.

14. An apparatus for use in determining an alternate route from a new source location located on an original route to a subsequent location on the original route, including

means for determining a portion of the original route to be avoided by the alternate route, the portion of the original route beginning at the new source location, and the portion of the original route including a plurality of segments each of which has an original parameter associated therewith,

means for adjusting selected ones of the original parameters thereby resulting in a plurality of adjusted parameters, and

means for determining the alternate route from the new source location to the subsequent location based in part on the adjusted parameters.

15. A vehicle navigation system, including

a plurality of sensors for detecting a current vehicle position and a vehicle heading, and for generating signals indicative thereof,

a database medium having geographic locations of a plurality of road segments and segment nodes stored therein,

a processor coupled to the sensors and the database medium for generating an alternate route from a new source location located on an original route to a subsequent location on the original route, the processor being operable to

(a) determine the portion of the original route to be avoided by the alternate route, the portion of the original route beginning at the new source location, the portion of the original route including a plurality of segments each of which has an original parameter associated therewith,

(b) adjust selected ones of the original parameters thereby resulting in a plurality of adjusted parameters, and
(c) determine the alternate route from the new source location to the subsequent location based in part on the adjusted parameters, and

an output communicator coupled to the processor for communicating the alternate route to a user of the vehicle navigation system.

16. A computer program product for determining a route from a source location to a destination, including

a computer-readable medium, and
a computer program mechanism embedded in the computer-readable medium for causing a computer to perform the steps of

determining a portion of the original route to be avoided by the alternate route, the portion of the original route beginning at the new source location, and the portion of the original route comprising a plurality of segments each of which has an original parameter associated therewith,
adjusting selected ones of the original parameters thereby resulting in a plurality of adjusted parameters, and
determining the alternate route from the new source location to the subsequent location based in part on the adjusted parameters.

FIG. 1

FIG. 2
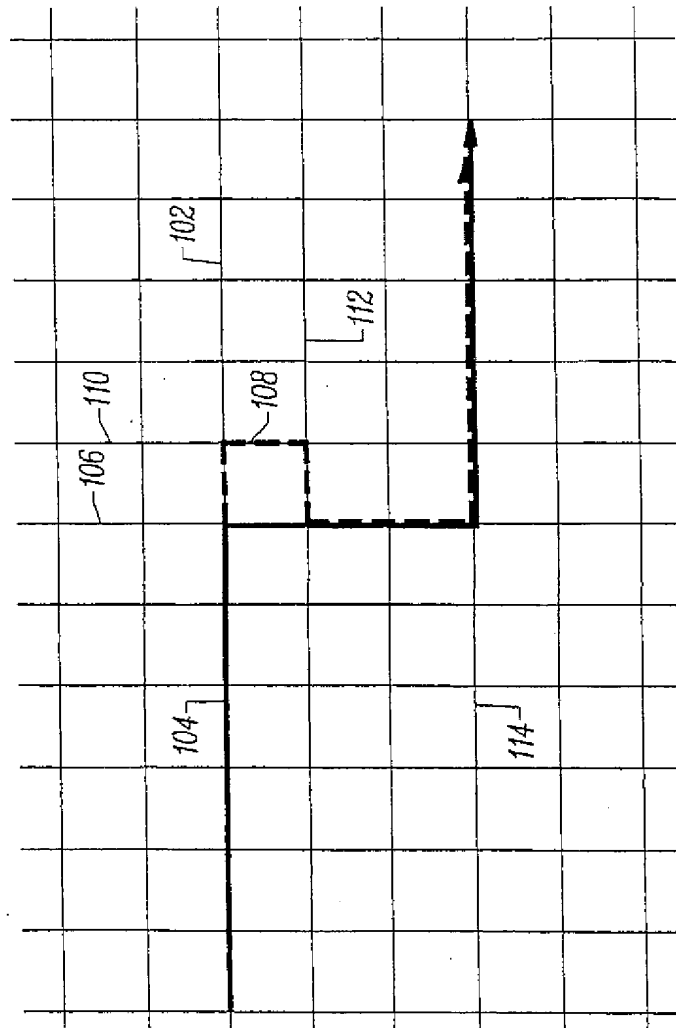
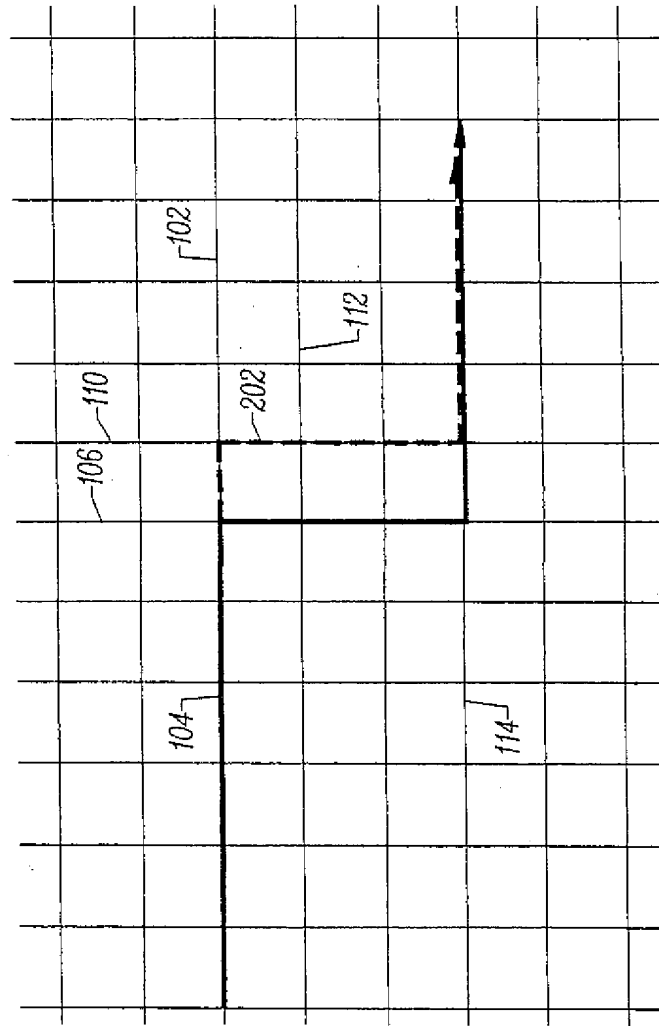*FIG. 3*
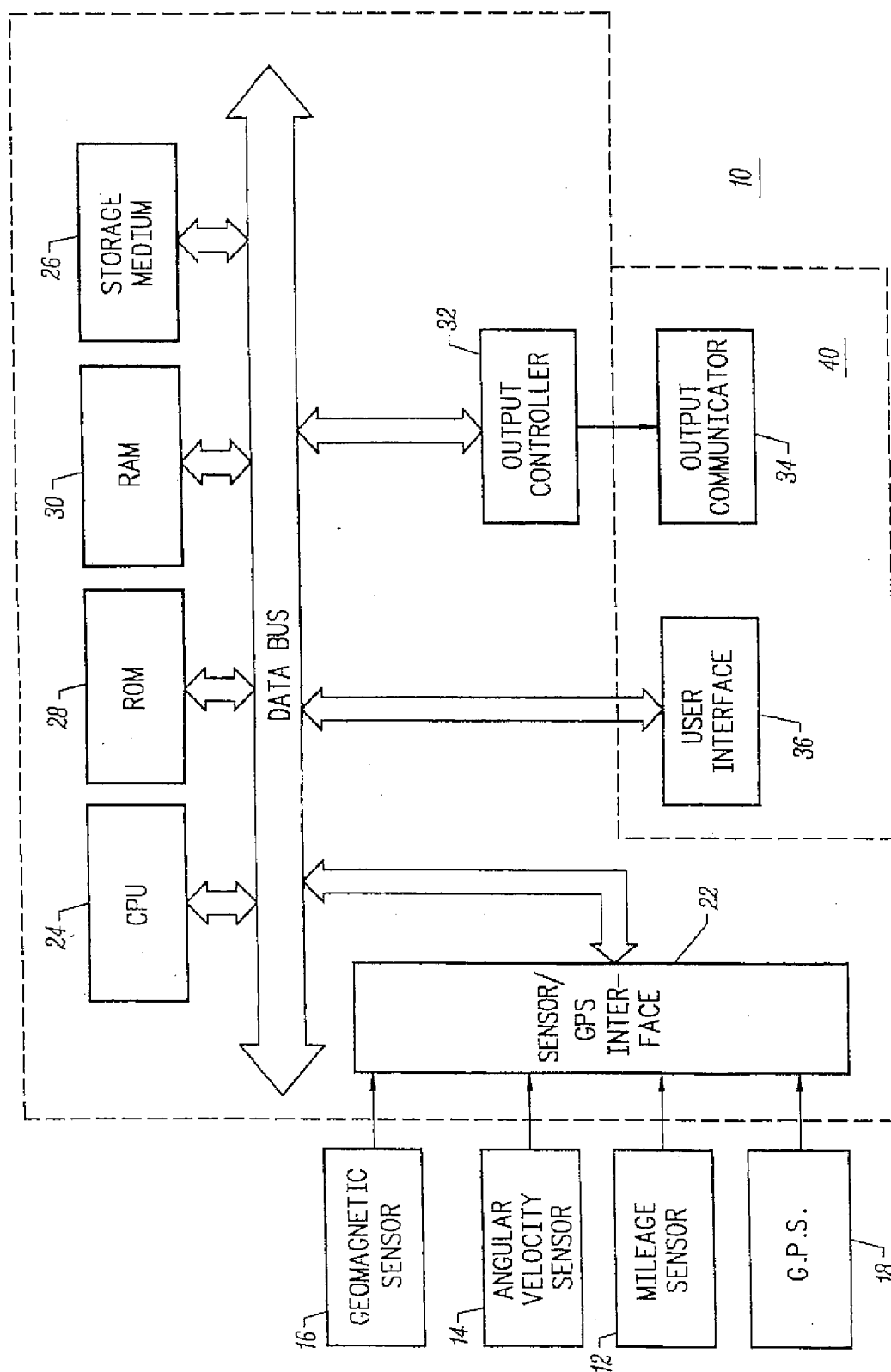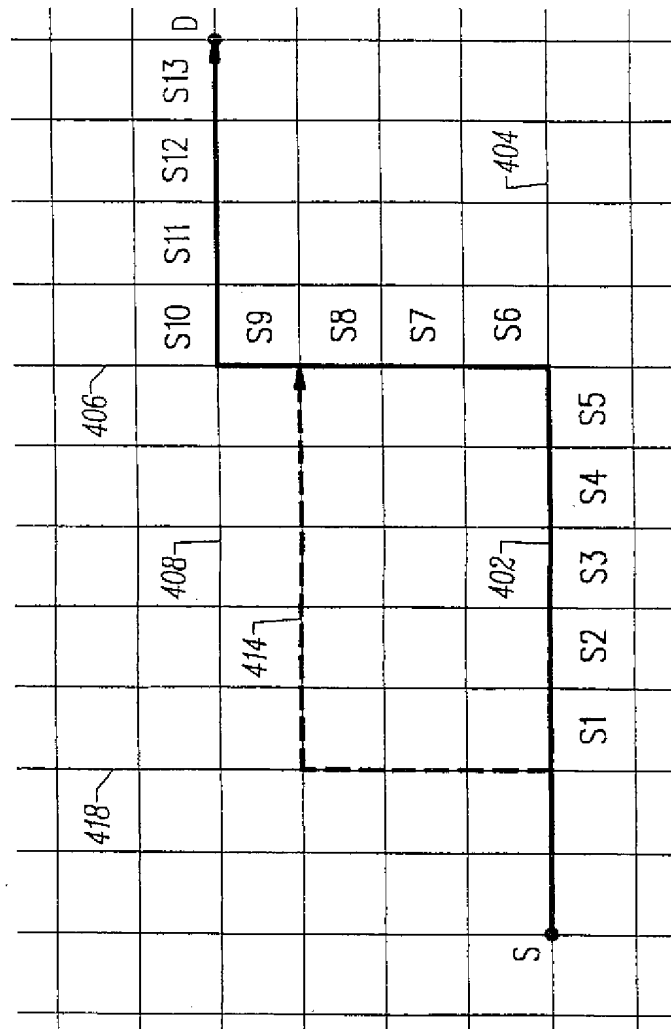
FIG. 4A

10

AVOID CURRENT ROUTE

Next 10 miles
Next 15 miles
Next 20 miles
Next 25 miles
Next 30 miles

412

Left turn at 418
0.1 miles

416

Left turn at 406
0.8 miles

410
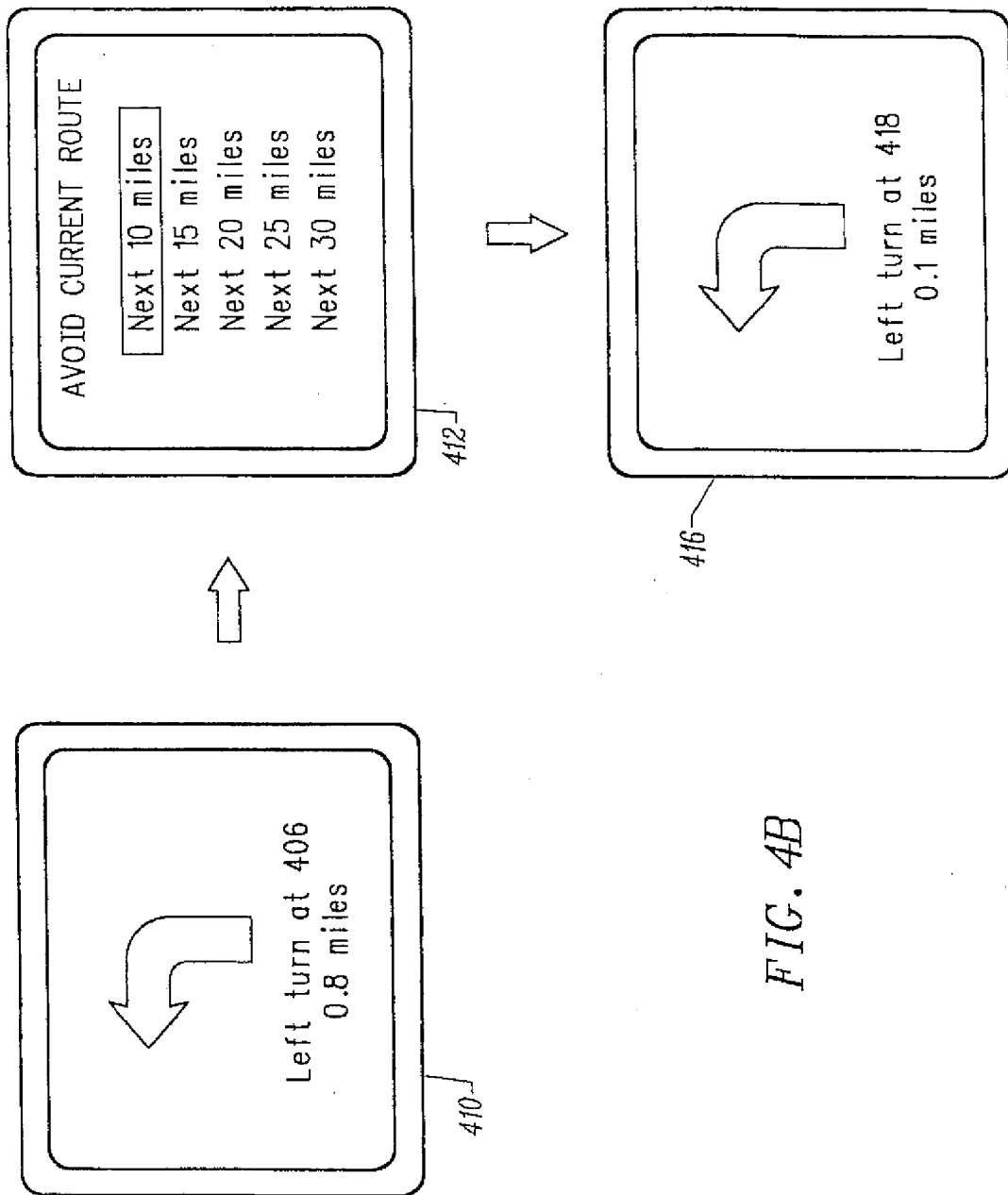
FIG. 4B

distance (miles)	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11 or more
cost (seconds)	100	90	80	70	60	50	40	30	20	10	0

500

FIG. 5

_600_

start

_601_

guide user along
original route

_602_

yes   receive
"avoid route" signal?   no

_604_

present "AVOID
CURRENT ROUTE" screen

_606_

yes   portion of
original route specified?   no

_608_

generate detour list

_610_

increase costs of
segments in detour list

_612_

generate
alternate route

_614_

yes   current alternate
route segment=original route segment?   no

end

FIG. 6